Sustainable Process Synthesis-Intensification

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Sustainable Process Synthesis-Intensification

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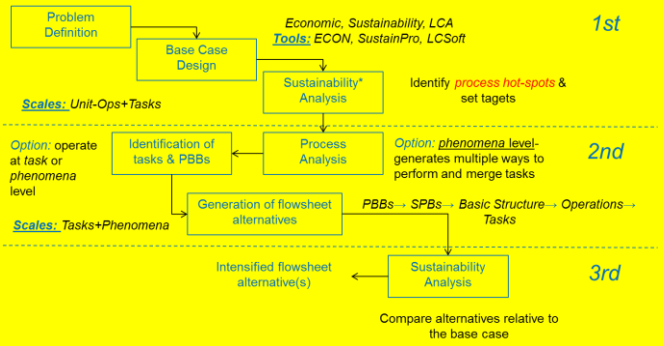
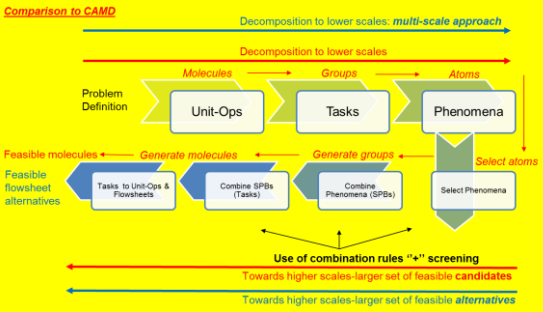
Introduction

Industry **needs improvements** related to:
-The use of sustainable technologies/processes
↓ Capital/Operation cost
-The efficient use of raw materials
↓ Waster generation
-The environmental and life cycle issues
↓ Energy consumption

Multi-level Framework



Concepts

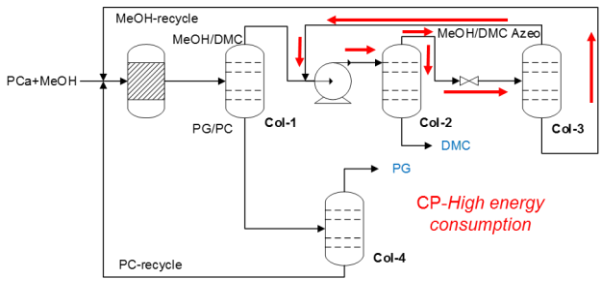


1st: Unit-Ops+Task scale

Problem Definition: Find intensified process design options for the production of DMC by minimizing the objective function:

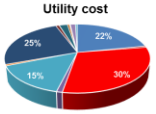
$$Min\, F_{obj} = \left(E_i C_{Ut,i} + \frac{C_{Equip}}{t_{proj}} \right) \Big/ m_{prod}$$

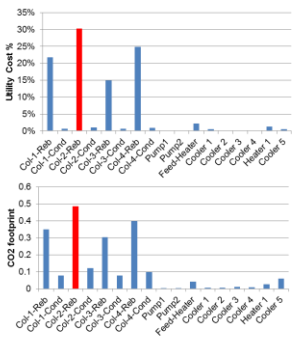
Base Case Design: Consists of 5 unit operations: 1 reactor and 4 distillation columns.



Sustainability Analysis: Consists of 5 unit operations: 1 reactor and 4 distillation columns.

Process *hot-spots* & *targets*





Economic, Sustainability, LCA:

1. ↑ Utility cost ↑ Energy Demand
2. ↑ Energy Demand ↑ EWC in CP
3. ↑ Energy Demand ↑ CO2 footprint

Targets (e.g.):

1. Reduce energy demand
2. Reduce number of Unit-Ops
3. Explore the possibility for using "hybrid" Unit-Ops
4. Improve Sustainability & LCA factors

2nd : Tasks+Phenomena Scale

Process Analysis (e.g.):

Thermodynamic insights

Excerpt of properties used for the generation of the binary ratio matrix

f_{ij}	Tb	RG	SolPar	VM
MeOH/PC	1.52	2.2	1.13	2.1
MeOH/DMC	1.08	2.09	1.46	2.09
MeOH/PG	1.36	2.03	1	1.82
PC/DMC	1.42	1.05	1.3	1.01
PC/PG	1.12	1.08	1.12	1.16
DMC/PG	1.27	1.03	1.46	1.15

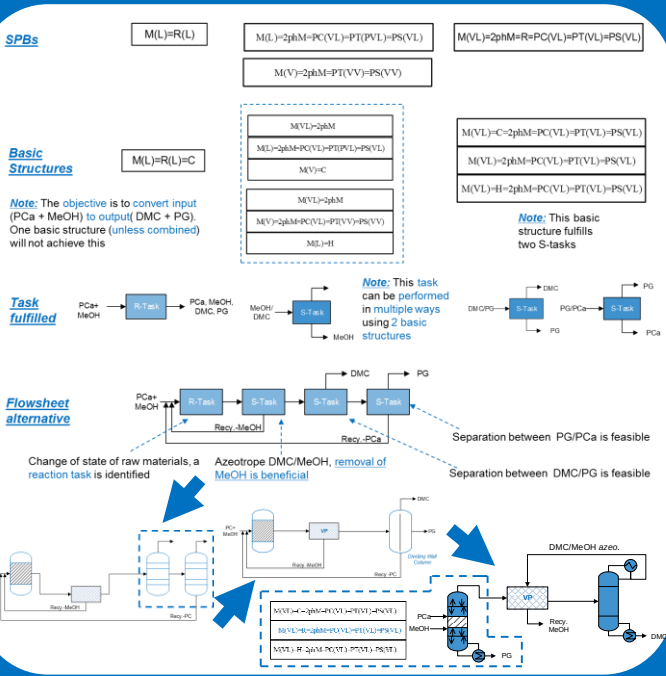
Tb *-normal boiling point*
RG *-radius of gyration*
SolPar *-Solubility parameter*
VM *-molar volume*

Hints separation based on molecular size possible

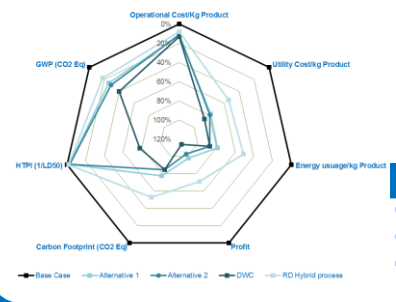
Identification of PBBs

Task	Component	PBBs
R-Task	PCa+MeOH	M,R,C
S-Task-1	PG_{LK}+PCa_{HK}	M,2phM,H,C,PC,PT,PS by VL
S-Task-2	$MeOH_{LK}$+PG_{HK}	M,2phM,H,C,PC,PT,PS by VL
S-Task-3	$MeOH_{LK}$+DMC_{HK}	M,2phM,H,C,PC,PT,PS by VL

LK-Light key
HK-Heavy key



3rd: Comparison



- Recall Targets
  - Reduce energy demand-Yes
  - Reduce number of Unit-Ops-Yes
    - Base Case = 8, Alternative 2 = 4 (DMC = 3, RD = 3
  - Explore the possibility for using "hybrid" Unit-Ops-Yes
  - Improve Sustainability & LCA factors-Yes

TARGETS HAVE BEEN MET

Conclusions

- A computer-aided systematic *multi-level* framework for performing process synthesis inclusive of process intensification has been developed
- For the DMC Case study *four* promising alternatives exist when compared to the base case design
- The concept of phenomena based PI is promising because it has been shown that feasible intensified flowsheet alternatives are generated at this lower scale